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Protocol for Organic and Sustainable Rice Production

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Abstract

The study aims to establish farming protocols for organic rice production and adopt the best farming practices in order to sustain the food supply needs of Filipinos for the whole year round and continuously year after year. The Randomized Complete Block Design with five treatments and five replications are laid out in twenty-five experimental plots with an area of twenty-eight square meters/plot. The treatments are the following: Control (commercial fertilizer), Protocol 1- vermicast with indigenous microorganism (IMO), fermented plant juice (FPJ), fermented fruit juice (FFJ) and Calcium Carbonate ($CaCO_3$); Protocol 2- vermicast with Agropower, and Delgro Microbial Inoculant (DMI); Protocol 3- Only vermicast and Protocol 4- combination of protocol 1,2 and 3s. The results of the study reveal that different farming protocols tested for organic rice production are not significant regarding the yield of rice at dry weight basis (14% moisture content). The results imply that the rice yield from the four farming protocols for organic rice production is comparable with rice farming using chemical fertilizers.

Keywords: farming protocols, farming practices,

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1.0 Introduction

Protocol for organic and sustainable rice production concerns about the step-by-step activities with the utilization of organic liquid and solid soil amendments applied in rice plants from planting to harvest and expected to sustain production all throughout the years for food production and food security. Liquid amendments in the form of indigenous microorganism (IMO), fermented plants juice (FPJ), fermented plant juice (FFJ) and fermented amino acids (FAA) are abundant and easy to prepare as sources of nutrients and pesticides for plant growth. Likewise, vermicast is available locally or can be purchased in the market. The procedures in vermicast production is one of the waste recycling activities which help mitigate climate change and global warming. Organic rice production enhances the fertility and nutrient of the soil by the activities of beneficial microorganisms. Products from organic farming contain less chemicals. Organic products are in great demand in the market because it promotes good health and environment-friendly community.

Organic agriculture contributes to global food supply while it reduces environmental pollution (Badgley et al., 2007). The organic crop production enhances biological activity, diversity and biological cycles and enhances more ecological harmony (Dela Cruz, 2014). Any product of plant or animal origin that has undergone substantial decomposition through biological, chemical, or any other process belongs to organic fertilizer that can supply nutrients to plants (Quin and Aganon, 2014). Furthermore, organic nutrient sources can perform comparatively well in terms of cooking quality than inorganic fertilization (Saha et al., 2007). Organic rice production does not use synthetic fertilizers and pesticides (Sullivan, 2003) and the quality is stable and seldom impacted by N inputs levels (Xi et al., 2009). Organic rice production is sustainable and environmentally- friendly. In terms of quality and nutrients, rice grown organically is comparable with that of rice grown conventionally (Quin & Aganon, 2014)

Farm waste like rice straws, plant leaves, grasses and animal manures are abundant raw materials for vermicomposting, while rotten fruits and fish and beneficial microorganisms can be processed as sources of plant nutrients and pesticides (fermented fruit juices, fish amino acids and indigenous microorganism). The utilization of these materials in right proportion with the combination of vermicast is a good source of organic soil amendment and should be encouraged as a partial substitution of inorganic fertilizers should be considered for long-term yield trends and soil fertility (Bi et al., 2009).

Vermicomposting is considered as a green technology to bio-convert rice residues and other biodegradable materials into nutrient-rich organic fertilizers (Shak, 2014), which contains N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, the uptake of which has a positive effect on plant nutrition, photosynthesis, the chlorophyll content of the leaves and improves the nutrient content of the different plant components (roots, shoots and the fruits) and also contains humic acids and phenolic compounds such as anthocyanins and flavonoids which may improve the plant quality and act as a deterrent to pests and diseases (Theunissen et al., 2010). Studies comprising vermicompost, fertilizers N and bio-fertilizers achieved higher yields and sustain soil health (Jeyabal and Kuppuswamy, 2001). Organic and sustainable farming has the potential to reduce environmental burdens (Hokazono et al., 2009). The use of organic soil amendments fill the gap of expensive synthetic fertilizer for rice production by practicing waste recycling, utilizing the raw materials derived from farm by-products, manures, grasses and plants leaves that are converted into vermicast by night crawler worms which are good sources of plant nutrients as organic fertilizer.

Combined organic/inorganic fertilization could both enhance Carbon storage in soils and reduce emissions from N fertilizer use while contributing to high crop productivity in agriculture (Pan et al., 2009). The maximum grain yield in 2008 (4335.88 kg/ha) was noted in plants treated with 2 ton/ha organic fertilizer and it was (4662.71 kg/ha) for 2009 for plant treated with the combination of chemical fertilizer with 1.5 ton/ha organic fertilizer (Siavoshi et al., 2011). Study showed that Masipag organic rice (yield= 2,683.0 kg) was not significant to Chemical farming (yield= 2,626.0 kg) in the Visayas region in Philippines (Medina, 2011). Organic rice farming utilized only 39 USD/ha of the cash capital required to grow a hectare of rice

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when compared with conventional farm which spent 118 USD/ha and organic farming improved the soil quality (Mendoza, 2004). A doubling in global food demand projected for the next 50 years poses huge challenges for the sustainability both of food production and of terrestrial and aquatic ecosystems, specifically the demands of improving yields without compromising environmental integrity or public health (Tilman et al., 2002). Hence, the production of organic rice through the best organic rice farming protocols will sustain food productivity.

Specifically, this study found out the efficacy of vermicast with the addition of fermented concoctions like indigenous microorganisms, oriental herbal nutrients, fermented fruit juice, fermented plant juice, and fish amino acids in the yield of rice. Vermicast and fermented concoctions are the source of plant nutrients for rice production. The fermented products contain beneficial microorganism that revitalizes and heals the futile soil for sustainable production and would produce healthy food products which promote good health of consumers.

2.0 Materials and Methods

The experimental research was used in the study employing the Randomized Complete Block Design. The NSIC Rc 346 rice variety was used, and laid out in 5 treatments and 5 replications with an area of 4 m x 7 m per plot. The study started on September 6, 2015 and ended on December 15, 2015, at West Visayas State University-Calinog Campus. The materials were rice seeds, IMO, FPJ, FFJ, FAA, calcium carbonate, vermicast, molasses, water, AGROPOWER, DELGRO microbial inoculant as NFS products and commercial fertilizer.

In this study, the fruit juices were extracted and allowed it to ferment for 7 day period with an addition of molasses or brown sugar. The fermented products were mixed with water with a ratio of 10 ml fermented concoctions to every 1 li water and applied to rice in a recommended time and place. The experimental layout and treatments are presented in figure 1.

Figure 1. The experimental layout and treatments in RCBD with 5 treatments and 5 replications

Block 1	Block 2	Block 3	Block 4	Block 5
A	E	B	E	A
B	D	C	B	B
C	A	D	A	E
D	B	E	C	D
E	C	A	D	C

Legend: A = Control (chemical fertilizer), B = Farming Protocol 1, C = Farming Protocol 2, D= Farming Protocol 3, and E = Farming Protocol 4

Plate 1. The experimental layout and treatments in RCBD taken 3 days before harvest

Preparation of Treatments (Quin and Aganon, 2014 and Sandig Jr., 2014)

Indigenous Microorganism (IMO) Preparation. Placed 1 kg cooked rice, into the container, covered with clean cloth and tied with string. Covered the container with plastic for protection from the rain. Exposed the container with rice to a forested area or place it near the bamboo plant litters for 3 to 5 days. Avoid exposure of materials to direct sunlight. Then harvest the materials by removing the moldy rice from the container and place it in plastic pots, then add 1 kg of molasses. Be sure that the container was only 70% full. Ferment for seven days, the mixture yielded a mud-like juice. Filtered the juice and placed it into a clean bottle, and covered it with paper or cloth. The mixture was ready for use in plants. The IMO, revives soil nutrients, speed-up composting, and plant growth.

Fermented Plant Juice. The ingredients were 1 kg banana stalk/bamboo shoots/green plants and one-half kg crude sugar or 0.5 li molasses. The preferred ingredients were chopped and mixed together, then covered with a clean sheet of paper. Place the mixture in a shaded environment and fermented for 7-10 days. The extracted juice was applied as an enhancer for plant growth and photosynthesis. In this study, banana plants were used as fermented juice.

Fermented Fruit Juice. The ingredients were 1 kg ripe fruit (pineapple, banana, avocado) and 1 kg crude sugar or 0.5 li of molasses. The ripe fruits were chopped and mixed with sugar and molasses, then placed in a jar and cover with a clean sheet of paper for 7-10 day fermentation period. Strained and applied it to rice as the source of nutrients, plant hormones, and protection against plant disease. In this study, pineapple fruit was used as a fermented fruit juice.

Fish Amino Acids Preparation. The chopped 1 kg of fish was mixed with 1 kg of molasses. Then placed the mixture inside the clay pot or plastic container with cover, using a paper or clean cloth and tied with string. Placed the container in a dry, cool place and out of direct sunlight. After 14 days of fermentation, filtered and placed the liquid into a clean bottle, covered with clean cloth or paper. Then stored it in a cool and shaded area. The mixture was ready for use with recommended dosage of 5.0 ml per liter of water as the source of nitrogen, growth hormones and amino acid to plants.

Calcium Carbonate ($CaCO_3$) Preparation. The chicken eggshells were gathered, then dried and crushed. The 1.0 kg crushed eggshells were pan fried until brown and crispy. The crushed eggshell was cooled down and added with vinegar placed in a container or clay pot. Wait until the bubbles appeared and covered it with clean cloth and tie with string. Allowed the mixture to ferment for 20 day period. Filtered and poured the liquid into the container and covered with a clean cloth for longer self-life. The mixture was ready for use, and stored it in a cool place away from direct sunlight.

Vermicast Preparation. Substrate materials were gathered with the mixture of rice straw, banana stalks/leaves, and grasses.

These substrate materials were chopped/shredded and mixed to carabao/cow manures with 3:1 ratio. The 30 days pre-decomposition was done and after which, the African Night Crawler earthworms were introduced. The vermicomposting was completed after 30-45 days. The end product of vermicomposting was called "vermicast."

Natural Attractant for Flying Insects (NAFI) Preparation. Prepared 1 kg molasses and mixed to 1 gallon of water. The solution was ready for use as a trap to flying insects in the area. The solution was placed in an open plastic bottle, half-filled and hanged along the side part of the rice paddies, 20 meters apart.

Protocols for Organic Rice Production (Quin and Aganon, 2014 and Sandig Jr., 2014)

Protocol 1

Soil Conditioning. Twenty-two days before transplanting, the first field plowing and application of vermicast at 2 tons per hectare was completed. Sprayed with one liter each of the Indigenous Microorganism (IMO) Fermented Plant Juice (FPJ), fermented fruit juice (FFJ), and fermented amino acids (FAA) per sprayer load during 21 days before transplanting. Second plowing was completed in 14 days before transplanting.

Seed and Seedling Preparation. Forty kilograms of seeds per hectare soaked in water for 36-48 hours and seed incubation period of 24 hours was completed. Three days before first plowing, seedbeds were prepared to an area of 800 m^2 for seedling growing added with composted rice hull on the top of the seedbed.

Land Preparation. One day before transplanting, and after the last plowing, and harrowing, the field was sprayed with one liter each of IMO, FPJ, FFJ, and FAA per sprayer load followed by leveling the field. Then, pulling and transplanting of seedlings were done. For rat protection, a ratio of 1:1 kg of cement and roasted milled rice were mixed together and positioned in strategic places where rats are evidently present.

Vegetative Stage of Rice. During 14, 28 and 42 days after transplanting, IMO, FPJ, FFJ, and FAA of one liter each were sprayed in the field using knapsack sprayer. At 39 days after transplanting, the natural attractant for flying insects (NAFI) was installed 20 meters apart along the boundary of the field against the flying insect pest. At 42 days after transplanting, Calcium Carbonate ($CaCO_3$) was sprayed to obtain a synchronized flowering of plants.

Productive Stage of Rice. NAFI bottle traps were positioned continuously above the ground until panicle emergence and $CaCO_3$ at the rate of 0.25 liter per sprayer load was applied to ensure the development of filled grains. Checking and removing unwanted rice were done to ensure purity of harvest. Harvesting started when rice reached 80% maturity.

Protocol 2

Soil Conditioning. Twenty-two days before transplanting, the first field plowing and application of vermicast at 2 tons per hectare was completed. Sprayed 2 kilograms/hectare of DELGRO Microbial Inoculant (DMI) dissolve in 160 liters with additional of 25 milliliters of HUMUS WSG per tank load of a sprayer. Second plowing was completed in 14 days before transplanting.

Seed and Seedling Preparation. Forty kilograms of seeds per hectare soaked in 160-liter water for 36-48 hours with 500 ml AGROPOWER and seed incubation period of 24 hours was completed. Three days before first plowing, an area of 800 m^2 for seedling growth was prepared with composted rice hull on the top of the seedbed.

Land Preparation. One day before transplanting, and after the last plowing, and harrowing, the field was sprayed with 0.5 kg DMI dissolved in 16 liters of water. For rat protection, a ratio of 1:1 kg of cement and roasted milled rice were mixed together and positioned in strategic places where rats were evidently present.

Vegetative Stage of Rice. During 14, 28 and 42 days after transplanting, 25 ml each of AGROPOWER and Humus WSG were sprayed in the field using knapsack sprayer. At 39 days after transplanting, the natural attractant for flying insects (NAFI) was installed 20 meters apart along the boundary of the field against the flying insect pest. At 42 days after transplanting, calcium carbonate ($CaCO_3$) was sprayed to obtain a synchronized flowering of plants.

Productive Stage of Rice. NAFI bottle traps were positioned continuously above the ground until panicle emergence and $CaCO_3$ at the rate of 0.25 liter per sprayer load was applied to ensure the development of filled grains. Checking and removing unwanted rice were done to ensure purity of harvest. Harvesting started when rice reached 80% maturity.

Protocol 3

Soil Conditioning. Twenty-two days before transplanting, the first field plowing and application of vermicast at 4 tons per hectare was completed. Second plowing was completed in 14 days before transplanting.

Seed and Seedling Preparation. Forty kilograms of seeds per hectare soaked in water for 36-48 hours and seed incubation in a 24 hour period was completed. Three days before first plowing, an area of 800 m^2 for seedling growth was prepared with composted rice hull on the top of the seedbed.

Land Preparation. One day before transplanting, and after the last plowing, harrowing and leveling the pulling and transplanting of seedlings were done. For rat protection, a ratio of 1:1 kg of cement and roasted milled rice were mixed together and positioned in strategic places where rats were evidently present.

Vegetative Stage of Rice. At 39 days after transplanting, the natural attractant for flying insects (NAFI) was installed 20 meters apart along the boundary of the field against the flying insect pest. At 42 days after transplanting, Calcium Carbonate ($CaCO_3$) was sprayed to obtain a synchronized flowering of plants.

Productive Stage of Rice. NAFI bottle traps were positioned continuously above the ground until panicle emergence and $CaCO_3$ at the rate of 0.25 liter per sprayer load was applied to ensure the development of filled grains. Checking and removing unwanted rice were done to ensure purity of harvest. Harvesting started when rice reached 80% maturity.

Protocol 4

Soil Conditioning. Twenty-two days before transplanting, the first field plowing and application of vermicast at 2 tons per hectare was completed. Sprayed with one liter each of the Indigenous Microorganism (IMO) Fermented Plant Juice (FPJ), fermented fruit juice (FFJ), and fermented amino acids (FAA) per sprayer load during 21 days before transplanting. Second plowing was completed in 14 days before transplanting.

Seed and Seedling Preparation. Forty kilograms of seeds per hectare soaked in 160-liter water for 36-48 hours with 500 ml AGROPOWER and seed incubation period of 24 hours was completed. Three days before first plowing, an area of 800 m^2 for seedling growth was prepared with composted rice hull on the top of the seedbed.

Land Preparation. One day before transplanting, and after the last plowing and harrowing, the field was sprayed with one liter each of IMO, FPJ, FFJ, and FAA per sprayer load followed by leveling the field. Then, pulling and transplanting of seedlings were done. For rat protection, a ratio of 1:1 kg of cement and roasted milled rice were mixed together and positioned in strategic places where rats were evidently present.

Vegetative Stage of Rice. During 14, 28 and 42 days after transplanting, 25 ml each of AGROPOWER, and Humus WSG were sprayed in the field using knapsack sprayer. At 39 days after transplanting, the natural attractant for flying insects (NAFI) was installed 20 meters apart along the boundary of the field against the flying insect pest. At 42 days after transplanting, calcium carbonate ($CaCO_3$) was sprayed to obtain a synchronized flowering of plants.

During Productive Stage of Rice. NAFI bottle traps were positioned continuously above the ground until panicle emergence and $CaCO_3$ at the rate of 0.25 liter per sprayer load was applied to ensure the development of filled grains. Checking and removing unwanted rice were done to ensure purity of harvest. Harvesting started when rice reached 80% maturity.

Notes: Spray early in the morning, before sunrise using ordinary (unchlorinated) water. Use only equipment and machinery intended for organic production. Carbonized rice hulls will be finely screened as possible before using in the seedbed. No chicken dung or hog manure from industrial sources.

The following parameters were observed:

The Yield of Rice. The yield of rice in kilogram (kg) per hectare was gathered and recorded. At 105- 110 days after sowing the rice plant was harvested. The harvested rice has undergone post - harvest handling and processing by drying, winnowing, weighing and storing with an estimated moisture content of 14% during storage.

Weighing of Rice Yield. The weight of harvested rice (kg) was taken after sun drying, and winnowing with the use of clock type weighing scale. The estimated moisture content of dried rice was 14% during weighing and storing. The yield of rice in kilograms/ hectare was converted into tons/ hectare.

The gathered raw data were arranged, tabulated and analysed using the Analysis of Variance in RCBD, generated from the Statistical Tool for Agricultural Research (STAR) software.

3.0 Results and Discussion

The highest yield with a mean of 4.41 t/ha is obtained by Farming Protocol 1 and the lowest has a mean of 3.65 ton/ha obtained by the Control (inorganic fertilizers). The result reveals that farming protocol 1 (mean yield of 4.41 ton/ha) with the used of vermicast 2 t/ha, sprayed with IMO, FPJ, FFJ, FAA and calcium carbonate applied to rice, produces more yield than other farming protocols including the control. The study of Siavoshi et al., (2011) showed that the maximum yield of rice in 2008 was 4335.88 kg/ha treated with 2 ton/ha organic fertilizer. The present study with a mean yield of 4.41 ton/ha was somewhat increased due to the application of IMO, FPJ, FFJ, FAA. However, the differences in the mean yield of 5 experimental treatments which ranges from 3.65 ton/ha to 4.41 ton/ha do not show significant result. Analysis of variance in Table 2 reveals that the observed F-Value of 2.42 (Treatment df= 4 and Error df = 16), is lesser than the Tabular F-Value of 3.01 at the 5% level, therefore, the statistical result is not significant in terms of the yield of rice. The result implies that the four farming protocols for organic rice production were comparable to control treatment, (inorganic fertilizer) in the yield of rice. Another study of Medina (2011) showed that Masipag organic rice in Visayas region, Philippines, was not significant to Chemical farming. The detailed results are displayed in tables 1 and 2.

4.0 Conclusion

The vermicast as organic fertilizer with fermented concoctions and indigenous microorganism are effective in the production of organic rice. The organic rice farming protocols produced a maximum mean yield of 4.41 tons in a hectare after the experiment. However, the result is not significant. Organic rice production is comparable with those rice farming using chemical fertilizers regarding the yield performance of rice. Minimal pest infestation are observed when rice plant is applied with IMO, FPJ, FFJ and FAA during vegetative and reproductive growth until harvest.

Table 1. Yield of rice (ton/ha) with different organic farming protocols

Treatments	Blocks					Total	Mean^{ns}
	I	II	III	IV	V		
Control (inorganic fertilizers)	4.66	4.43	2.88	3.86	2.43	18.26	3.65
Farming protocol 1 (organic fertilizers)	5.29	4.86	4.54	4.11	3.25	22.05	4.41
Farming protocol 2 (organic fertilizers)	5.46	4.64	4.04	3.68	3.84	21.66	4.33
Farming protocol 3 (organic fertilizers)	5.32	4.68	3.70	3.68	4.09	21.47	4.29
Farming protocol 4 (organic fertilizers)	4.57	4.82	4.79	3.50	3.43	2.11	4.22
Grand Total						104.55	
Grand Mean							4.18

C.V. = 10.45%
ns – not significant

Table 2. Analysis of variance table for yield of rice in Table 1

Source of Variation	Degrees of Freedom	Sum of Squares	Mean of Squares	Observed F-Value	Pr Value	Tabular 5%	F-Value 1%
Block	4	9.1695	2.2924	12.00	0.0001		
Treatment	4	1.8476	0.4619	2.42^{ns}	0.0914	3.01	4.77
Error	16	3.0565	0.91				
Total	24	14.0736					

C.V. = 10.45%
Yield Mean = 4.18
ns – not significant

5.0 Recommendation

The researcher recommends the adoption of organic rice farming protocols for sustainable and environmentally-friendly agriculture. The mass production of vermicast and fermented concoctions should be encouraged for use in rice production. Farmers can utilize vermicast with IMO, FPJ, FFJ, FAA and calcium carbonate as the source of organic plant nutrients and pesticides for rice production.

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